REVIEW.

ART. XII.—*Mémoire sur l'empoisonnement par l'acide arsénieux.* Par M. ORFILA. Lu a l'Academie Royale de Médecine, Jan. 29, 1839. Annales D'Hygiène, vol. xxi.

Mémoire sur un nouveau procédé pour constater facilement, dans nos organes, la présence d'une préparation arsénicale qui aurait été absorbée. Par M. ORFILA. Ibid, vol. xxii.

Mémoire sur les terrains des cimetières, sur l'arsenic qu'ils peuvent fournir et sur les consequences médico-légales que l'on doit tirer de l'existence possible d'un composé arsenical dans ces terrains. Par M. ORFILA. Ibid., vol. xxii.

Mémoire sur l'arsenic naturellement contenu dans le corps de L'Homme. Lu a l'Académie Royale de Médecine, le 24 Septembre, 1839. Par M. ORFILA. Ibid., vol. xxii.

Mémoire sur les moyens de s'assurer que l'arsenic, obtenu des organes ou il a été porté par absorption, ne provient pas des réactifs, ni des vases employés a la recherche médico-légale de ce poison. Par M. ORFILA. Ibid, vol. xxii.

Mémoire sur l'empoisonnement par l'arsenic; nouveau procedé pour retrouver l'absenic absorbé, &c. Par M. ALPH. DEVERGIE. Ibid., vol. xxiii.

Observations sur le dernier mémoire de M. A. Devergie. Par M. ORFILA, Ibid, vol. xxiii.

On the means of detecting arsenic in the Animal Body and of counteracting its effects. By J. LAURENCE SMITH, M.D., of Charleston, S. C. Dated Paris, Dec. 6, 1840. (Silliman's Journal, vol. lx.)

British and Foreign Medical Review, No. xxi, *for Jan.* 1841. *Art.* 2—*Review of Orfila's Memoirs on Poisoning.*

THE primary objects of investigation in legal medicine during the last two years have been—the detection of the principal mineral poisons in minute quantities—and the nature of insanity as excusing from the responsibility of criminal acts. We propose in the present article to consider the first of these and to present to our readers, a condensed historical view of the discoveries, and improvements that have been made, together with a notice of the discussions to which they have given rise.

Prior to the period just named, the introduction of Mr. Marsh's apparatus was the most prominent recent improvement. This is in fact an apparatus for producing arseniuretted hydrogen, while by the combustion or that gas, metallic arsenic can be obtained and collected.

In a memoir read by Professor Orfila, before the Royal Academy of Medicine in Paris in Jan. 1839, the question which he proposed to consider was as follows. *When arsenious acid has been introduced into the digestive canal, or applied to the sub-cutaneous cellular tissue, can it be*

detected in the blood or in the organs of the animal economy, with which it has not been placed in contact? The following are some of his experiments.

With solid arsenic in fine powder. Twelve grains were inserted inside of the thigh of a dog and the wound was closed with several sutures. In three hours, vomiting occured and death followed during the night. The matter rejected gave no trace of arsenic with Marsh's apparatus, nor could any be detected in the urine, bile, or blood. The stomach, liver, heart, lungs and brain were then boiled for an hour in distilled water and the products examined separately, but with similar ill success. It now became a question whether the quantity absorbed might not be so small as to prevent its detection. A small bag, containing eighteen grains, carefully sewed up and dried was next applied to the cellular tissue as before, and the edges of the wound were united by suture. The animal died after vomiting in eight hours. The bag on being withdrawn and dried, weighed $16\frac{}{10}$ grs., having lost $1\frac{4}{10}$ of a grain of arsenic. In similar experiments with smaller and larger quantities, he found that about the same quantity was lost in each. It now occurred to our author that in the previous experiments, he might not have prolonged the boiling of the viscera sufficiently. He adopted the following course. Having applied two grains of solid arsenic as usual inside of the thigh, he after death, dried the brain, lungs, heart, liver, spleen, digestive canal, and kidneys separately in porcelain capsules, having previously added to each a few drops of the solution of potash in alcohol. Each of the viscera was then pulverized with its weight of nitrate of potash; the mixture burnt in small quantities in a Hessian crucible, and the ashes treated with water and sulphuric acid. All these liquids gave traces of arsenic with Marsh's apparatus. He then in another experiment, boiled all the above organs together, evaporated the liquor down to two ounces, and found indications of the poison. Again, the skin and bones of the same animal (but not the limb to which the arsenic had been applied) were boiled as before, and in order to get rid of the jelly produced, the product was boiled with nitro-muriatic acid and then evaporated almost to dryness. On adding water to it and employing Marsh's apparatus, arsenic appeared in eight minutes, and the quantity of it was sensibly larger than that obtained from the viscera.

Experiments with arsenic in solution. Eighteen grains dissolved in three ounces of water were introduced into the stomach of a young dog and the œsophagus was then tied. Death ensued in three hours. The digestive canal was immediately removed, without being wounded or discharging a drop of the fluid contained in it. The blood, urine and bile were then collected and tested with the apparatus, but no traces of the arsenic could be found. So also when the heart was boiled down with distilled water. He then boiled down with water the brain, lungs, liver, spleen and kidneys, and the liquor after being evaporated and concentrated to one-tenth of its volume was tested and gave indications of arsenic. Various muscles of the trunk and extremities were submitted to the same process, with a successful result.

The body of this dog had not however been subjected to these trials, until eighteen hours after death, and it might hence possibly be urged, that the poison had reached the parts in question by imbibition. To meet such an objection, he in one instance, destroyed a poisoned dog by hanging, at the time when it appeared to be dying, and in another killed it eighty-five

minutes after taking the poison. In both, the blood when treated as before, gave traces of arsenic, as did also the various viscera and the muscles.

Comparative experiments were instituted with the viscera and bones of dogs and man, known not to have been poisoned, or to have taken arsenic, and in no case, could he detect any traces of the poison with Marsh's apparatus.

In all his experiments, Orfila had used porcelain dishes of various sizes, whenever any animal substances were to be boiled. Aware however that these may not always be attainable, he repeated the processes both in copper and iron vessels, and with both succeeded in obtaining arsenic. He accordingly recommends their use, advising at the same time, to commence the investigation, with substances free from poison and to submit these to the usual tests.

He now proceeded to ascertain whether the process of Rapp is the most efficient for obtaining the largest portion of arsenic. One sixteenth of a grain in Marsh's apparatus produced upwards an hundred large brown spots on the porcelain capsules, but when the same quantity, mixed with some dried intestine had been deflagrated with nitre and then treated with water and sulphuric acid, the liquor gave only a few fawn coloured spots, showing evidently that a *notable portion of arsenic had been dissipated.* So also when the same quantity of arsenic, having been previously mixed with a drachm and a half of powdered glue was projected gradually on melted nitre for the space of fifteen minutes, the product treated as before gave scarcely a trace. But when to the same mixture, nitre was added and the whole triturated together and then burnt for five minutes, arsenic was distinctly manifested. Again, when nitre and arsenic were added to a mixture of broth and bile, and the same process was pursued, by evaporating the mixture to dryness, gradually burning it and then treating it as before, the poison was readily detected.

It would thus seem, that by adopting the process of Rapp, a portion only of the organic matter is perfectly burnt—some is merely carbonized, and a portion of the arsenic is hence volatilized. It is evidently preferable previously to unite the organic matter with nitre, so that both can be dried together.

The next point to which our author directed his attention was whether all the arsenic in a solution is precipitated by sulphuretted hydrogen. He boiled a portion of the human body with the eighth of a grain of arsenic—allowed the liquor to cool so as to separate the fat, and then treated it with sulphuretted hydrogen. A yellowish brown precipitate was produced, which after decanting off the liquor, he placed on the filter, washed it with solution of ammonia until it would take up no more, and then on applying heat to drive off the ammonia, obtained an impure sulphuret of arsenic. This was now boiled with nitric acid in order to procure sulphuric and arsenic acids, and the product placed in Marsh's apparatus indicated the presence of the poison.

The decanted liquor was next evaporated down to one-half of its bulk. It deposited additional organic matters, and when filtered was mixed with an ounce of nitre. This was reduced to dryness, burnt in a Hessian crucible, and the ashes were treated with water and sulphuric acid. The liquid, when submitted to Marsh's apparatus, yielded as much arsenic as the sulphuret had in the previous experiment. The same result was

obtained in several successive trials with various materials, and this even when the decanted liquor was not boiled, but allowed to stand for ten days in order to clear itself, and then mixed with nitre.

The inference to be drawn from these results is too manifest to need remark. We should always examine both portions—the precipitate and the remaining liquor.*

Process for discovering a soluble arsenical preparation when it has been absorbed.—After washing the body with distilled water, the skin, muscles, blood-vessels and viscera should be cut into small pieces and the bones broken down into small fragments. Place the whole in a large copper or iron vessel, having previously added ten or twelve grains of solid alcoholized potash, and pour on distilled water sufficient to cover the whole mass. It must then be boiled for six hours, taking care to add water every half hour to supply the loss from evaporation. Filter the liquid carefully through fine linen, and when it becomes cool, and the fat has separated, divide this last again into small pieces and boil it in distilled water another hour to dissolve the arsenical acids or salts that it may contain. This liquid should be added to the other.

After slightly acidulating the fluid with muriatic acid, it should be submitted to a current of sulphuretted hydrogen gas for at least two hours. This process is not, however, according to our author complete, unless the whole be now boiled for ten or fifteen minutes, since, if the poisoning has been produced by arsenic acid, or an arsenite, or a soluble arseniate, the precipitate will not form except at a high temperature. After a proper time the liquor is decanted and the precipitate collected on a filter. The latter contains the sulphuret and organic matter. Wash it frequently with ammonia, and then add nitric acid sufficient to saturate the ammonia and to precipitate the sulphuret, which will now take on its characteristic yellow appearance. Remove all the fluid from it by a pipette and dry it. It may now be submitted to the usual processes recommended by writers, but if we wish to apply the apparatus of Marsh, this sulphuret should be heated in a porcelain capsule with a few drops of nitric acid, so as to convert it into sulphuric and arsenic acids. The dried product is then dissolved in distilled water, and is ready for the experiment.

The decanted liquor should now have added to it about a pound of pure nitre. Evaporate the mixture to dryness and then project portions of it in an earthen crucible heated to redness, in order to ascertain whether there is nitre sufficient to burn the animal matter. This we may suppose to be the case, if the ashes are yellow or green, but if they are black and carbonaceous, an additional portion of powdered nitre should be added to the mass. The whole is then successively deflagrated, and the product is found to consist of nitrate of potash in excess, carbonate of potash—arseniate of potash, (the arsenious acid having been converted into the arsenic,) with various other salts and insoluble matters. Wash the ashes with distilled water, add sulphuric acid from time to time until all effervescence ceases. The liquor now consists of sulphate of potash and arse-

* The action of sulphuretted hydrogen on arsenic mixed with animal matter is quite uncertain. In some instances it cannot be made to produce its characteristic yellow, and we must then resort to other processes. But in no case are we, according to Orfila, (*Médecine Légale,*) *immediately* to expect its effect. Many hours must frequently elapse before the change of colour takes place, and he has known a period of eight, nine, or ten days to pass before a precipitate was formed.

nic acid, and the nitrous gas that it contains must be driven off by boiling for ten minutes. Then allow it to cool, the insoluble portions and the greater part of the sulphate of potash will precipitate, and the decanted liquor will, on being tested by the apparatus of Marsh, exhibit indications of arsenic.

M. Orfila next proceeds to consider the apparatus of Marsh, mentions some objections to it, and proposes a modification. He also notices the stains produced by antimony, and how far they resemble those from arsenic. As this branch of the investigation will require a reference to the labours of other medical jurists, we postpone a notice of it for the present. If the presence of arsenic be suspected in the liquid vomited, or in those contained in the digestive canal, and if either be mixed with organic matters, let the liquor be filtered, and then pass into it a current of sulph. hydrogen gas, adding some drops of muriatic acid to assist the precipitation. Allow sufficient time for that purpose, and then reduce the sulphuret in order to submit it to the apparatus of Marsh, or apply the tests usually recommended. We must here also recollect that the fluid decanted from the precipitate still holds arsenic in variable quantities in solution; and in order to ascertain this, let it after filtration be mixed with pulverized nitrate of potash heated to dryness. The product must be incinerated, treated with water and sulphuric acid, and is then ready for the apparatus.

It may be useful to enumerate some of the conclusions deduced by Orfila from the above experiments. 1. Arsenious acid, introduced into the stomach, or applied to the subcutaneous cellular tissue of dogs, is absorbed. It passes into the blood and is carried into all the organs of the animal economy. 2. When it is placed in fine powder upon the tissue, no matter in what quantity, only a grain and a half will be absorbed, and this causes death. 3. That it is absorbed when taken into the stomach, either in a solid or fluid state. 4. That similar effects will be produced on man, although larger doses may be necessary to induce death. 5. That it is indispensable by chemical means to ascertain the presence of arsenic thus absorbed, and particularly so, if we cannot find it in the matters vomited, or in the fluids of the digestive canal. 6. For this purpose, we may treat several of the muscles, or one of the viscera of the body, previously well dried, but it is preferable to employ the whole or at least the half of the entire body, as the portion of poison absorbed is often so small as to yield an uncertain result with less. 7. That the presence of arsenic may be detected in the blood of a person poisoned, provided we act on a number of ounces. Venesection is indicated in these cases, not merely because it is an antiphlogistic, but as it also presents us with a means of withdrawing from the circulation, a portion of the absorbed poison. 8. The presence of arsenic, detected by the process described above, in parts of the body with which it was not originally placed in contact, proves incontestably that the poison was taken during life. 9. Although it may hereafter be proved, that there exists naturally in some parts of the human body an arsenical compound, yet it has been clearly shown by experiment that this compound is insoluble in boiling distilled water. The value of the process is hence not impaired.

In a subsequent memoir, published in October 1839, Orfila commences by conceding that the nitrate of potash process is complicated and tedious. He is hence induced to advise the substitution of another that he has found

more simple and expeditious. It is the carbonization of the organic matter after it has been well dried, with pure concentrated nitric acid.

Take the liver, lungs, spleen, or any other organ, or a certain quantity of the blood supposed to be poisoned, and dry it thoroughly. Then treat this with pure, concentrated, nitric acid in a porcelain vessel or capsule. The proportions which he advises are as follows:—For three ounces of dried blood, seven ounces of acid are required; for six ounces of dried cerebral matter, two pounds and four ounces; for both lungs dried, and weighing five and a half ounces, a pound of acid; for the heart weighing after drying one ounce six drachms, five ounces; for twelve ounces of dried liver, thirty-four ounces of acid; for the stomach and intestinal canal dried and weighing three ounces, nine ounces; and for muscle as dry as possible, and weighing twenty-two ounces, four pounds and four ounces. For the other organs, nearly in the same proportion according to their affinity to the parts already named.

The details of the process are thus given:—The whole of the acid is to be poured into the capsule, which is then placed over a gentle fire. Add gradually fragments of the dried organ until the whole is dissolved. Nitrous gas will be copiously evolved. If too much of the animal matter has been added at once, an enormous quantity of froth (*mousse*) is formed, which may boil over and cause the loss of some arsenic. The liquor, which at first was yellow, now becomes orange-coloured, and finally a deep red; it is also thickened. The process of carbonization commences on the circumference, but we must not remove the vessel from the fire, until a thick black smoke begins to escape from the whole mass. After allowing the vessel to cool, the charcoal, which is light, friable, and more or less greasy, must be collected and powdered in a mortar. It is then boiled for twenty minutes in seven or eight ounces of water, so as to dissolve the arsenic acid formed by the action of nitric acid on arsenic. The filtered liquor is then submitted to Marsh's apparatus.

The residuum of the charcoal may be mixed with a proper proportion of nitre, dried and then burnt in a Hessian crucible. If it be then treated with sulphuric acid and tested as already directed, we may occasionally find, even in this, minute traces of arsenic.

Our author states that he has successfully employed this method in the following instances:—A dog was poisoned with twelve grains of arsenious acid introduced into the stomach. The blood, heart, lungs, liver, spleen, kidneys, and the product of an aqueous decoction of the limbs were each submitted to the action of nitric acid, and the carbon obtained from their decomposition gave notable indications of the presence of arsenic. The stomach of Soufflard, a poisoned individual, was boiled in distilled water, and the liquid treated with sulphuretted hydrogen gas. At the end of three months there was a copious deposit of sulphuret of arsenic on the filter. The remaining liquor, almost transparent, was now evaporated to dryness, and carbonized by nitric acid. This dissolved in boiling water, and tested by Marsh's apparatus, produced a number of arsenical spots. A portion of the liver of Lorrin, who had poisoned himself, was submitted to the same process with similar results. Again, Mercier, a person supposed to have been poisoned, was disinterred a fortnight after death, and the usual chemical examinations were instituted without success. Four months afterwards, the body, in a state of putrefaction, was again raised. The liver and limbs were submitted to the carbonizing process, and a

great number of arsenical spots were obtained. Lastly, a female took arsenic in fine powder in a cup of coffee. Twelve hours afterwards she was bled. Orfila received about ten ounces of the blood from Casimir Broussais, dried it carefully in a porcelain capsule with four grains of alcoholized potash, and then decomposed the product, weighing two and a half ounces, with five ounces of nitric acid. The resulting charcoal, treated with boiling water, and submitted to Marsh's apparatus, gave numerous small arsenical stains, little coloured, but brilliant.

Remarkable as are these results, the reader must however understand that there are difficulties which may impede or prevent the success of similar experiments. Unless the organ be thoroughly dried, the process will be tedious, and so large a quantity of froth will be produced, as to endanger the loss of the arsenic. It would also seem that great nicety is required in the carbonizing process. From a number of experiments, Orfila deduces the following conclusions. 1. In using nitric acid to detect absorbed arsenic, we must avoid carbonizing the soft parts rapidly and with flame, or slowly, so as to disengage a pyrogenous odour; in either case the greater part, if not the whole, of the arsenic will be lost. 2. The loss of arsenic will be in proportion to the quantity of organic matter that is experimented on. 3. The best mode of extracting arsenic, is to carbonize the organs in an instant, without flame or ignition, and with the production of a thick smoke, and of a bulky and spongy charcoal. Even this, however, will not extract all the arsenic contained in the tissue.

It will be seen, from these cautions, that the author is not perfectly satisfied with the process in question. He is fearful of the loss of a portion of the poison, and therefore introduces a repetition of the sulphuretted hydrogen process given in the first memoir. After going through the preliminary steps, he advises the examination of the precipitate in the manner there recommended; but the filtered liquid, although no longer affected by sulph. hydrogen may still contain arsenic, and for the detection of this, he directs that it be evaporated to dryness and treated with the nitric acid process. The remains of the viscera left after making the decoction in water, should also be dried and submitted to the same test. If there are materials sufficient, both processes should be employed, and Orfila distinctly states, that in several instances, without resorting at all to the sulphuretted hydrogen process, he has proceeded at once to act on the dried organ with nitric acid.

We come next to the consideration of three memoirs by Orfila, in which the possibility of the presence of the arsenic, other than from poison, is discussed. The questions to be solved are the following. 1. *Does arsenic exist naturally in the human body?* 2. *Does it exist in the earth of grave-yards?* 3. *Is arsenic contained in any of the apparatus or reagents that we employ for ascertaining its presence.*

1. *Does arsenic exist naturally in the human body?*—Courbe, a French chemist, supposed that he had found it in the animal tissues, when in a state of putrefaction, but distrustful of his accuracy, requested the aid of Orfila in continuing the inquiry. That individual subsequently confirmed the fact, and conscious of the important bearing of this point on the new mode of analysis proposed by him, extended his experiments so as to meet all proper objections. The following are his deductions. Arsenic exists in human bones. If these be calcined, taking care not to raise the temperature too high, (this may volatilize the arsenic,) and also to avoid

contact with the fuel, an ash will be obtained of a grayish colour, mixed with black spots; this must be powdered and sifted, treated with sulphuric acid, three ounces to eight ounces of ash and water is subsequently to be added from time to time; after digesting for several days, the mixture is to be boiled, and taking care to supply the loss by evaporation with water. The filtered liquor is now submitted to Marsh's apparatus, and yields brown, brilliant, and thick arsenical spots. This result was obtained from the bones of the corpses of adults, who had been dead some days, or buried several months. When the calcination is effected at a white heat, no arsenic is obtained, nor is any procured from the bones of commerce reduced to a soft paste, but if they be subjected to heat, and to the processes indicated, (nitric acid, potash, and sulphuric acid,) a certain quantity of arsenic is obtained. Orfila infers from his series of experiments, (*a*) that the bones of the human adult, of the ox, sheep, and dog, contain minute portions of arsenic, which it is possible to discover with pure potash and pure sulphuric acid; (*b*) that the quantity of arsenic is not increased by long burial; (*c*) that it is preferable to employ the paste phosphate of lime in experiments, instead of the vitrified phosphate, as the arsenic is partly volatilized during the vitrification; (*d*) that the condition most favourable for the detection of arsenic, is when the bones have not been too intensely calcined, nor have been in contact with the fuel: (*e*) *that it is impossible to obtain an atom of arsenic when they are simply boiled in water.* In case this should be practised and arsenic should be discovered, we must believe that it has been absorbed in some way or other, and not that it belongs to the arsenic naturally found in the bones.

No arsenic could be found in the viscera.—All the organs of a dog were treated separately by the processes already described, but without any effect. The blood, brain, liver, spleen, intestines, and stomach of an adult gave no traces of it. At present, therefore, we may assert, that with the nicest tests no arsenic can be detected in the viscera. *It is not proved that the muscles contain arsenic.*—Twelve pounds, taken from the corpse of an adult, dried and then carbonized by nitric acid, and tested by Marsh's apparatus, gave some white opaque spots, and others of a bluish or yellowish tint, but they possessed none of the characteristics of arsenic. It is possible, however, says Orfila, that other processes *may discover it, and he therefore puts his proposition in the above terms.*

The application of these results to a medico-legal case, is evident. The viscera are the organs on which we should depend for decisive appearances, and our author advises, in order to avoid any cavil, that all the bones or fragments of them should be carefully removed before commencing our experiments.

2. *Is arsenic contained in the earth of grave-yards?*—It may happen that human remains require to be examined, after the coffin is decayed, and they have become mixed with the earth—or rain may have dissolved a portion of the superincumbent materials and united it with the body. In either case, the above question acquires some interest.

Orfila supposes that the earth of several grave-yards, containing, however, more or less of bony fragments, gave *slight* indications of arsenic, by boiling with sulphuric acid, evaporating and submitting to Marsh's apparatus. From others, however, he could not obtain a trace. But when the viscera of bodies found in the above arsenical earths were examined, no indications of the poison could be discovered. From experi-

ments, also, he deems it highly improbable that earth which contains a soluble arsenical compound, can yield it to a decayed human body, so as to give it the indications of poisoning.

If, therefore, a body be so much decayed that it forms part of the earth, and we find an arsenical compound soluble in cold water, and cannot, at the same time, detect the arsenic in the ground within a few feet of this spot, the safe opinion is, that the poison has been furnished by the body, and not by the earth.

3. *Is arsenic contained in any of the apparatus or reagents that we employ for ascertaining its presence?*—This constitutes the subject of an elaborate memoir. He notices the various articles in order. *Sulphuric acid.* Vogel of Munich, Wackroder, and Berthels, have each detected the presence of arsenic in this substance. The first of these concludes from his experiments, that it occurs more or less in the concentrated acid made in leaden chambers, but that it does not occur in the German fuming sulph. acid. Wackroder found it in an acid, called English, but which is probably from Bohemia, and is used extensively in commerce. (*Journal de Chimie Médicale.*) Again, Vogel asserts that distilled sulphuric acid is perfectly free from it; and lastly, he states, that arsenic, when present, always occurs in the form of arsenious acid.

The experiments of Orfila lead him to the following conclusions. Should arsenic be present, it probably exists in the form of arsenious and arsenic acids —a mixture of both. The arsenical sulphuric acid, if the poison be not in too small quantity, may be detected by introducing a portion of it, *with four or five times its weight of water*, into a vessel containing sulphuretted hydrogen gas. The liquor assumes a yellow tinge, and after a time deposits sulphuret of arsenic mixed with sulphur. Collect this on a filter—wash it repeatedly with diluted liquid ammonia, so as to dissolve all the sulphuret. The ammonia, if now treated with pure nitric acid, will abandon the sulphuret. These directions should be strictly followed, since the *concentrated* sulphuric acid, if used, may, by this operation, form yellow spots of sulphur.

In more minute quantities, the presence of arsenic may be detected by using Marsh's apparatus. But our author avows distinctly, that he has not yet been able to obtain any commercial sulphuric acid from which he could procure the spots in question. He was obliged to experiment with the artificial compound, and when two hundred and fortieth of a grain of arsenic was added to the acid, he succeeded perfectly.*

Sulphuric acid can be completely purified of this substance by passing sulphuretted hydrogen gas through it: after some time filter the liquor through plates of amianthus. The sulphurets of arsenic will deposit themselves on this in different layers. Then boil the liquor to expel the remainder of the gas and distil.

No arsenic has yet been detected in *nitric acid*, but we may, if doubtful, test it by Marsh's apparatus. *Nitrate of potash* is also free from it. But it may be decomposed with concentrated sulphuric acid, and after getting rid of all the nitric acid, saturate with potash—then heat it with three or four ounces of water, so as to dissolve any arseniate or arsenite of potash that may have been formed. Filter and wash off the sulphate of potash, and submit the residuum to Marsh's apparatus. *Zinc* is said

* There seems to be some contradiction here, as I certainly understand M. Orfila to say, in other parts of this memoir, that he has met with arsenical sulphuric acid.

to contain arsenic, so also *iron*. It is however remarkable that the same arsenical sulphuric acid, which readily produces spots, on being tested, will not present any when acting on zinc and a small quantity of water. In five hundred experiments with zinc, Orfila detected the presence of arsenic only three times. If any doubts exist concerning it, try it with water and sulphuric acid, and cause both a strong and feeble flame. It may be made perfectly pure by reduction from the sulphate of zinc. Our author could not detect the presence of arsenic in cast iron vessels that were employed in experiments, nor does he imagine it probable that they would give it up (if present) to the decoction of animal matter, particularly when the acids of this have been saturated, as directed, with pure potash. They should be well cleansed, after every trial, with a solution of potash and rubbed bright. So also with Hessian crucibles, porcelain vessels, glass tubes, &c. It is all important that they retain no arsenic from previous experiments. The glass tubes used in Marsh's apparatus should have a small and well rounded aperture, if otherwise, the arsenical matter may be condensed on them and not deposit itself on the capsule.

While engaged in the investigations from which the memoirs which we have now analyzed were prepared, several medico-legal cases occurred that called for their immediate application. Two of these, from the interest that they have generally excited, deserve a particular notice. The first has been already alluded to.

Case of Mercier.—Louis Mercier, the father of several children, one of whom was of weak intellect, married a second wife. The latter was very frequently heard to express her disgust at being compelled to live under the same roof with the idiot boy, whose habits were extremely unclean and revolting. On one occasion, the father was heard to say, in reply to some of her remarks, "Never mind, it will soon be over." On the 13th of December 1838, he purchased an ounce of arsenic at an apothecary's shop. On the 15th, his son was seized with vomiting: this continued for several days, but no medical aid was asked or given, and death ensued on the 22d. None of the matters vomited were recovered.

A fortnight after death the body was disinterred on suspicion. There was acute inflammation of the digestive canal, with minute ulcerations of the mucous membrane, particularly at the large curvature of the stomach. The liquid found in the stomach and intestines was carefully tested with sulphuretted hydrogen, and subsequently with Marsh's apparatus. Failing in the detection of any poison, the chemists of Dijon then took the stomach and intestines, cut them into fragments, boiled them with nitric acid, passed a current of sulphuretted hydrogen gas through the liquor, and subsequently applied the apparatus of Marsh, but in none of the experiments was there a trace of arsenic discoverable. The moral proofs of the poisoning, however, became stronger every day. Orfila was officially consulted, and by his advice, the body was again disinterred in April, four months after it had been first buried. The remains of the corpse were sent to Paris (eighty miles,) to be again examined. What remained of the intestinal canal bore no longer any trace of organic structure, and all the other parts were more or less disfigured. It was to this mass of flesh, half decomposed, that he had to apply his new method. He performed the examination with the assistance of Devergie, Le Sueur and Ollivier (D'Angers,) and obtained indications of the presence of poison, (arsenical spots,) not only from the liver and limbs, but also in the

fluid of the cask in which the body had been transported. They therefore gave it as their opinion, taking into account the symptoms, the appearances on dissection, and the present results, that Mercier the son had been poisoned. Devergie alone was unwilling to go thus far, but he conceded that there was a highly probable presumption of poisoning, provided Mercier had not used any arsenical medicines shortly before death, and also, if the ground in which he had been interred did not contain arsenic.

The advocates of the accused were not inactive. They invoked the assistance of Dr. Rognetta of Paris, apparently a bitter enemy of Orfila. He did not hesitate to assert that the appearances found on dissection proved nothing more than the presence of disease; and he deemed the results of the chemists of Dijon as conclusive against the existence of poison. By his advice, Raspail, the chemist, was consulted. His answers were so favourable, that he was summoned as a witness, and appeared before the Court of Assizes in that capacity, to the great astonishment of Orfila, (says the reporter,) who was not aware of his coming.

The so called deposition of Raspail is nearly equal in length to a three hours' congressional speech. It is in fact an address to the jury, in which the subject of poisoning by arsenic is elaborately argued. Every opportunity is at the same time seized to weaken or destroy the value of the experiments of the opposing witness. However the manner of this production, and its gross personalities may be condemned, yet it contains some remarks worthy of consideration.

He contends that when, after failing to detect either solid or fluid arsenic in the digestive canal, we proceed to look for it in the tissues, we must recollect, that the poison in small quantities may have been introduced either accidentally, or as a medicine. The arseniate of copper forms the principal constituent in the colour of green paper hangings. The emanations from this when damp may be inhaled. There are also many occupations—such as the whitesmith, the tinman, &c., in which small portions of arsenic may enter or pass into the circulation. Suppose, (says he,) you should put into Orfila's iron pot the body of one of the workmen in our silver mines which contain a notable proportion of arsenic, would it not produce, by his mode of proceeding, a vast number of arsenical spots?

Again—is it not possible that the poison may pass by infiltration into a body laying five months in the grave? At all events, these and many other causes may explain the presence of arsenic in *imponderable quantity* without necessarily resorting to the idea of poisoning.

In answer to a question of the president judge, asking his opinion of Marsh's apparatus, he replied that this was not a new discovery, but an improved instrument. Chemists had long known how to make arseniuretted hydrogen—they were acquainted with its inflammability, and that on being fired, it deposited metallic arsenic, or with a higher heat, arsenious acid. The apparatus of Marsh was intended to exhibit these effects on a small scale—to operate, in fine, on minute portions of arsenic, and this is accomplished by forcing the gas through a small tube and directing its flame on a plate of porcelain.

The tests formerly in use had failed in preserving their distinctive characters. The ammoniaco-sulphate of copper turned green with the juice of coffee not burnt as well as with arsenic. The phosphates and onion juice produced similar results with arsenic or nitrate of silver. Then Marsh's apparatus was announced. A single spot is deemed sufficient,

and this spot may be *antimony*. They are *visible* but *imponderable* spots. You throw aside quantitative tests and adopt infinitesimally small ones. This is *homœopathic legal chemistry*.

To these and many similar suggestions, Orfila replied that all the tests used by him had been most carefully examined previous to the experiments, that Marsh's apparatus was resorted to, only because the others had not proved sufficiently minute—that the spots obtained presented four distinct characters; they were brilliant, exhibiting the appearance of metallic arsenic, were volatilized by heat; they dissolved in nitric acid, and this being evaporated, left a yellowish white residuum, which when treated with nitrate of silver, gave a brick red precipitate, the arseniate of silver. If Raspail would point out any other substance, than arsenic, possessing these four characters, he would instantly tear his report in pieces and abandon his opinion.

If the doctrine as to grave-yards be admitted, we should be altogether precluded from ascertaining the presence of poison in any body after it had been disinterred. But he denied the fact altogether. He had disinterred two bodies from ground ascertained to be arsenical, and could not find a trace of arsenic by the tests in question. At four different times also, several pounds of the earth surrounding the body of Mercier had been analyzed, and on only one occasion was there a very slight trace of arsenic, and even here it was necessary to employ boiling sulphuric acid.

Orfila denied that coffee juice would produce a similar green, and even if it did, the garlic smell would be wanting. Raspail accepted the challenge of his opponent, as to the four distinctive characters. A vast number of substances (said he) are soluble in nitric acid—every substance of an animal nature when treated with it becomes yellow—while the alkaloids redden from its application. Again, let an essential oil, coloured, be mixed with phosphate of ammonia, a salt quite common in the animal tissues. This volatile mixture passed through the flame of hydrogen, will deposit spots on porcelain, having that metallic lustre which phosphoric acid gives to every substance half carbonized. These spots are soluble in nitric acid, which will colour them yellow. The phosphate will give a yellow precipitate with nitrate of silver; and the reaction of nitric acid on the organic matters present, may produce a brick red precipitate.

To these assertions, Orfila interposed a denial, and the court very properly closed the discussion, by directing an investigation of the spots on porcelain, which Orfila had obtained from the body, and now presented to the court as arsenical. Orfila, Sene, Payen and Raspail were appointed to superintend the analysis. Raspail acceded to this, protesting at the time, that although they were proved to be so, the charge of poisoning ought not to be considered as established.

At the end of a few hours, the commisson reported that they had compared the spots with others obtained that morning from a known quantity of arsenic—that they were identical—that they had noticed the garlic odour from both, and that on making comparative experiments with antimonial spots, the evaporated residuum after the action of nitric acid, gave a brick red with nitrate of silver to the arsenic, and a black to the antimony. They therefore reported that the spots presented by Orfila were arsenical.

Raspail indeed objected to this conclusion, and again addressed a long explanation to the court. He was followed by the advocates for the pri-

soners, when the cause was submitted to the jury. They acquitted the female, but found the father guilty *with extenuating circumstances*, and he was condemned to imprisonment for life.*

Case of Madame Laffarge.—The trial of this female has awakened great interest, and its leading facts are generally known. I will therefore be as brief as possible in stating the moral circumstances. The chemical testimony will require more of detail.

Although it appears like prejudicing the reader, yet it is necessary in preserving the order of time to state that Madame Laffarge (aged 24) was accused, tried, and convicted of having robbed a countess of certain diamonds. She interposed an appeal to a higher court, and that tribunal set aside the verdict, on the ground, that the prisoner had been accused of *poisoning her husband.* The trial for this crime came on, in September 1840, at Tulle, before the Court of Assizes of the Department of Correze. The evidence ran thus. Maria Capelle was married in August 1809, at Paris to M. Laffarge, through the instrumentality of her aunt, neither of the parties having had much previous knowledge of each other. The next day, they repaired to Glandier, where Laffarge had iron works. His wife seems to have repented of her union in a very few days—and desired a separation, declaring that she loved another. This dislike however appears to have gradually worn off, and a reconciliation took place. In October, Laffarge made an improvement in his process for manufacturing iron, and he communicated it to his wife, as probably promising future profit. He shortly after made his will in her favour, and she at the same time, returned the compliment.

Laffarge went to Paris, to take out a patent. The parties kept up an affectionate correspondence. On the 16th of December, Madame purchased some arsenic from an apothecary to poison rats. She on the same day, requested her mother in-law, to have some *small* cakes baked, in order to send, along with her portrait, to her husband. On the 18th he received but one *large* cake at Paris, and immediately ate a portion of it. During the night he was seized with colic and frequent vomiting, and remained in bed during the next day. It appeared in testimony, that at the same time, Madame Laffarge in the country, expressed fears lest a letter with a black seal should be received by her, and asked how long widows wore their mourning in the country, and said that she would not wear her weeds above one year as at Paris.

On the 3d of January, the husband returned weak and ill. She appeared affectionate, and in the evening requested him to partake of part of a fowl and truffles; he did so and was immediately seized with colic and vomiting. A physician was sent for, who considered the symptoms as those of intussusception. Incessant vomiting continued, with burning pain in the throat, colic, coldness of the body and diminished action of the heart. On the 5th Madame Laffarge procured more arsenic, by desiring the attending physician to write for it, in order to destroy the rats. Subsequently she obtained another portion through Denis, a person employed in the iron works, and whom she had requested to preserve secrecy. She had before this made no secret of having arsenic in her possession.

The family began to suspect her. She had used an egg emulsion, and

* Gazette Des Hopitaux for Dec. 1839, and Jan. 1840; Lancet, Dec. 14, 1839; American Journal of Medical Sciences, vol. 25, p. 487, from the Gazette Médicale.

her husband requested some of the same drink to be prepared for himself. It was brought to her room, and Miss Le Brun, who was then in bed in the same room, saw Madame Laffarge empty in it from a paper a white powder and stir the same with her finger. She inquired what the powder was, and was told by madame that it was orange flower. It was then carried to Laffarge, who refused to partake of it. Miss Le Brun, in examining it, noticed a white powder on the surface, and this being communicated to Laffarge, he desired that it should be given to an apothecary chemist for analysis. He detected arsenic in it, and this was subsequently corroborated by scientific chemists. On the same day, another drink was prepared for Laffarge, consisting of a small quantity of wine mixed with water, sugar and some bread. Miss Le Brun was in the room with the prisoner, and saw the latter take the glass containing the drink to a cupboard, and then heard a noise like that of a spoon coming in contact with another vessel. Madame presented a spoonful to her husband, who was in bed. He had no sooner partaken of it, than he exclaimed, "Ah Marie! what have you given me? It burns me." Miss Le Brun went to the cupboard and observed a sprinkling of white powder and a small pot containing a similar powder. Another witness testified to the same facts. The drink and the powder were examined chemically and were found to contain arsenic. On the same day the same young lady observed a glass containing water and a white powder, in the room of Laffarge. Madame Laffarge said it was gum water, and adding much water to it, drank a little, by way of showing that it was similar to her usual gum water beverage. In the night, she was seized with colic and vomiting.

On another occasion the mother of Laffarge saw the prisoner mix a powder with the drink of her husband. Friction with flannel had been ordered for the patient over the stomach. Madame Laffarge covered it with laudanum, and olive oil, and a white powder. Arsenic was detected in this by chemical analysis

Another physician, Dr. Lespinasse, was called in on the 13th. The above circumstances were communicated to him, and he prescribed the hydrated oxide of iron. Laffarge before death, shuddered on seeing his wife approach, and would take no food from her hands. On the morning of the 14th he died.

It is also stated, that although Madame Laffarge had obtained arsenic professedly for the purpose of killing rats, yet when the paste prepared by her order for this purpose was examined, no arsenic could be found in it.

Dr. Tournadour, D'Albay, Massenat, Bardou, Lafosse and Lespinasse examined the various fluids. The egg emulsion was treated with sulphuretted hydrogen, a few drops of muriatic acid were then added, and a yellow flakey precipitate fell down. This was soluble in ammonia. It was then treated with carbonate of potash and charcoal, and reduced to the metallic state. The same results were obtained with the panada and the sugared water. Arsenic was also detected on the flannel. The fluid contained in the stomach, when decolorized by animal charcoal, was mixed with an equal quantity of water, in which a portion of the stomach had been boiled. These fluids were boiled in a mattrass with a few drops of nitric acid; the fluid was then saturated with carbonate of potash, then an excess of sulphuretted hydrogen gas, with a few drops of muriatic acid was added, and a flakey precipitate of a yellow colour was the result. It

was collected on a filter, upon which equal parts of water and ammonia had been poured. The liquid, when again filtered and heated on the sand bath, left on drying a yellow residuum which was introduced into a glass tube, with carbonate of potash and charcoal. *Unfortunately, the tube broke, in the process of heating, and the contents were lost.*

Orfila was asked, whether the yellow precipitate obtained as above, and soluble in ammonia, was a sufficient proof of the presence of arsenic. His reply was in the negative—adding that all medical jurists required as indispensable, the reduction of the precipitate to the metallic state.

The court ordered a new analysis. M. M. Dubois and Dupuytren (brother of the late eminent surgeon) were requested to perform it. They examined a portion of the stomach—some of the liquid found in the stomach, and a portion of the matter vomited. They employed the method of Marsh, but could detect no arsenic. A brown flaky substance was obtained from the fluids, which proved to be a salt of iron.

The next order of the court was that the body should be disinterred, and a new series of experiments instituted on its remains. A large commission was appointed for that purpose. They reported that the liver had been treated with nitric acid, the result placed in a capsule, and evaporated; the residue was mixed with three times its weight of nitric acid. This was evaporated. When treated with distilled water, it resembled charcoal, and weighed two ounces. It was filtered, and sulphuretted hydrogen gas was passed into it. A yellow precipitate fell, soluble in ammonia; ammoniacal sulphate of copper gave a greenish precipitate, and nitrate of silver, a neutral yellow one, and ammoniacal nitrate, a yellowish precipitate. These precipitates, when examined by the apparatus of Marsh, gave no indications of arsenic.

In this contradictory state of the evidence, Orfila, Ollivier, and Bussy, were required to undertake another and final examination. They took the fourth part of the stomach which remained, and portions of the fluid found in the stomach, and of the matter vomited. The whole were evaporated to dryness, and then carbonized by nitric acid. The resulting charcoal was subjected for an hour, to the action of distilled water, and the liquor resulting therefrom, when filtered, was introduced into Marsh's apparatus. A number of small brown, and shining arsenical stains were obtained.

They next took a mixed mass from the organs of the thorax, and abdomen—a portion of the liver and of the heart, a certain quantity of the intestinal canal, and a part of the brain. This was boiled with distilled water for four hours, the liquid was strained and evaporated, and a portion of the residue dissolved. This decoction was evaporated, and carbonized by nitric acid. When treated in Marsh's apparatus, it gave arsenical stains. A portion of the solid matter left in the filter, was then subjected to the same process, but it was found almost impracticable to carbonize it in consequence of the presence of much fatty matter. This was, however, affected by previous deflagration with nitrate of potash—then boiling with sulphuric acid, and saturating the last with potash. The decanted liquor finally obtained, gave large brown and shining stains, and they were proved to be arsenical, by subjecting them to the nitrate of silver, which produced the arseniate.

The winding sheet, and the earth above and below the body were examined, but no trace of arsenic could be obtained.

In consequence of these results, Orfila supposed that Laffarge had been poisoned, although he conceded, that the quantity procured was extremely small. He had no doubt, that metallic arsenic would have been obtained, if the tube had not broken, and as to the second experiment, he explained the want of success, from operating on too minute quantities. So also in the third one, where only a portion of the liver was tested.

Madame Laffarge was found *guilty with extenuating circumstances*, and she was condemned to exposure in the pillory, and hard labour for life. On appeal to a higher court, the sentence was confirmed.*

* Lancet, December 26, 1840. There are also very full newspaper reports of the trial, which have been consulted in preparing the above. A great deal of fictitious sympathy has been excited for this female, and it has been lately asserted, that facts recently developed, tend to prove her guiltless of the robbery. But can any one doubt, after reading this trial, and even putting altogether aside the testimony of Orfila, that she administered arsenic knowingly to her husband?

N. B. After completing this article for the press, I received through the kindness of Drs. J. K. Mitchell and Hays, the Memoirs of Raspail presented to the Court of Cassation for the reversal of Madame Laffarge's sentence, and also his *Refutation* (in part) of Orfila's answer to the above, published in the *Gazette de Hôpitaux*, for December, 1840.

Much of these are of course a repetition of what has been already stated in the text, drugged in every part with extreme bitterness and personality. It is, however, proper to mention some of the explanations and criticisms of Raspail.

He objects that the arsenic found in the house was not sealed up, and placed under the care of a proper officer, so that its identity could have been proved without the shadow of a doubt. He suggests that Laffarge may have died from intestinal strangulation—from tape-worm—or even from the large quantity of colcothar administered to him as an antidote, and he also throws out the idea that the arsenical spots may have been derived from the metal contained in that substance. The large commission of chemists, and medical men, who operated on the liver, stomach, &c., and could find no arsenic, are highly spoken of; yet he concedes (page 77) that *they* obtained arsenic from the different powders found in the rooms of Madame Laffarge, although in the early part of the memoir, he advocates the idea, that they were merely gum arabic.

On Orfila, however, the full measure of condemnation is heaped. He should not have been summoned—his high rank in the profession gave too much weight to his opinions, when placed in opposition to country chemists. His experiments are questioned. It seems that he brought some nitrate of potash with him from Paris, and used it in his manipulations. This is repeatedly condemned, but I cannot say with what view, except to insinuate that it contained arsenic. By referring to the narrative, it will be seen that in two of his experiments, nitric acid was used, and in the third, this nitrate of potash. In the former case, the spots produced were faint, and small; in the latter, they were more numerous and striking. And strange to say, adds Raspail, the solids in this case produced more spots than the liquids of the body. In reply to his repeated remarks concerning the Parisian nitrate of potash, it is sufficient to state that the chemists at Tulle, in not a single instance employed that substance, and of course the inference suggested fails.

It will be recollected that Dupuytren and Dubois experimented without success, with Marsh's apparatus. Orfila appears to have said that they were possibly not sufficiently familiar with it—that they pushed the flame too high, and thus volatilized the arsenic. This idea is repelled with great indignation by Raspail, and he speaks in the highest possible terms of their practical skill as chemists.

The tests of arsenic are also examined, and shown in many instances to be uncertain and equivocal. Sulphuretted hydrogen may deposit sulphur instead of arsenic. This is conceded by Orfila, but he requires, in order to make the experiment available, that the sulphuret be reduced subsequently to the metallic state. The value of the brick red arseniate, produced by the nitrate of silver, is also questioned. Raspail asserts that it will cause a precisely similar deposit when added to a mixture of phosphate of ammonia and acetate of iron, and also when poured on an alcoholic solution of iodine.

Even the garlic smell is a subject of grave contention between these individuals.

I have already mentioned that the court of Cassation rejected the appeal.

Excited probably by the discussions on these trials, and at all events desirous of demonstrating the correctness of his views, Orfila again brought this subject before the Academy of Medicine, late in 1840. It appears that he had not extended his experiments to antimony also, and these we will notice hereafter. But as to arsenic, he undertook to prove, or rather re-affirmed its absorption through the digestive canal, or subcutaneous cellular tissue, mixed with the blood, into all the organs—that it remains for a time in the viscera and muscles, where its presence can be demonstrated, but that from the time of the poisoning, a part of the absorbed portion leaves the tissues, and is eliminated by the *urine*—that this elimination continues for several days, until the tissues have been completely freed from the presence of the poison—that Marsh's apparatus as modified is the best mode for detecting minute portions—that there exists in the bones both of man, and of several animals, an arsenical compound, insoluble in water, and which differs from the absorbed arsenic—that from the muscles of the human body, may be extracted a matter, which Orfila believes, to be formed of an excessively small proportion of arsenic, sulphur, and an organic substance; and finally, that in the earth of certain grave-yards, there are found quantities of arsenic infinitely small, which boiling water will not dissolve, but when treated with boiling sulphuric acid, he obtained stains from it.*

He then proceeded with his experiments on dogs. Several were poisoned—some by the introduction of arsenic into the stomach, and others by placing it below the cellular tissue. The urine was immediately examined after death, and he urges that in all medico-legal cases, this should be the first subject of notice—both during life and after death. On being submitted to Marsh's apparatus, it, in all the cases of poisoning, yielded manifest signs of arsenic, whilst that of a dog killed by hanging gave none. A very small portion of the liver of a poisoned dog was next carbonized, and the liquor prepared from it tested with the apparatus. Multiplied spots of arsenic were presented. When nearly all the organs of the suspended dog were submitted to the same process, not the smallest trace could be observed. He further proved that arsenic was not developed in the soft parts by putrefaction. He took a liver that had been twelve days in the dissecting room, far advanced in decomposition, carbonized the whole, and subjected it to the usual experiments without finding an atom of poison.†

Having thus endeavoured to present a full view of the important investigations of Orfila, and shown the severe ordeal to which they were immediately subjected on the trials just related, it only remains to consider the additional comments or criticisms which have appeared concerning them. And in doing this, I shall adopt the following order:

1. As to the absorption of arsenic.
2. The existence of arsenic as a natural constituent of the human body.
3. Its presence in the earth of grave-yards.
4. Its presence in consequence of having been used as a medicine.
5. Its presence in the reagents or apparatus that have been employed.

* In another report, it is stated as an opinion of our author, that arsenic or antimony remains in the interior organs, the liver especially, even when no traces of it are longer to be found in the urine. This would seem to contradict one of the results maintained in the text.

† *London Medical Gazette*, vol. xxvii, p. 302, 330. *Lancet*, November 14, 1840.

6. Marsh's apparatus—the objections to it—the modifications proposed —and the character of the stains produced.*

1. It will be recollected that in the early experiments of Orfila he applied small bags containing a given weight of arsenic to the cellular tissue, and after death, dried, and again weighed these. His inference was, that less than two grains was sufficient to produce death. It is objected to this, and apparently with reason, that the unavoidable admixture of the blood of the wound with the bag must render the deduction somewhat inconclusive.

It would also appear from the failure in his early experiments, that too small a quantity of blood had at first been operated on, and again, that the minute portion of arsenic present in it was probably concealed and protected from the action of chemical agents by the organic matter mixed with it. Hence the value of the new process—viz., incineration by nitric acid—which destroys to a great extent the animal matter.

In several additional instances, perfect success attended the examination months after death. "The liver from the body of N. M., suspected to have died from poison, and which had been interred for five months, was carbonized by nitric acid. The aqueous decoction yielded an abundance of arsenical stains."

"I obtained from the heart, mesentery, omentum, and a portion of the intestines of M. Cumant, a small quantity of arsenic. This person died in December 1838, his body was exhumed in July 1839, and the organs above mentioned were examined in the month of December following."—(*British and Foreign Med. Rev.*, vol. xi, p. 49.

2. *The Existence of arsenic as a natural constituent in the human body.*—As to the *bones*, the testimony is discordant and unsatisfactory Devergie, in order to meet the objection that sulphuric acid might contain the arsenic, instead of those organs, took 1000 grammes (a gramme being equal to about 15½ grains troy,) of the commercial phosphate of lime, and submitted one half to the action of sulphuric acid, and the other to that of pure muriatic acid. In either case he obtained by Marsh's apparatus arsenical stains, and they perfectly resembled each other. (*Annales*, vol. xxiv, p. 153.)

* In this arrangement I do not include the repeated attacks on the originality of Orfila. These, if correct, may impair his character as an honourable man, but do not injure the value of his improvements. Indeed, we desire, in legal medicine, an accumulation of testimony.

The most serious charge is that by Courbe. He asserts distinctly that he communicated to Orfila the circumstance that putrefying bodies contain arsenic, and that he had constantly found it in the bones and putrefying remains of grave-yards. The idea of Courbe was that the phosphate of lime may contain arseniate of lime, as we often find these salts mixed together. Orfila, however, will only allow that Courbe *announced* without *proving* the existence of arsenic in the human body.—*Gazette des Hopitaux*, December 19, 1839: *Annales D'Hygiene*, vol. xxiv, p. 313.

Dr. Rognetta pursues his adversary still further. "Valentine Rose," (says he,) "at the commencement of the present century, directed that the stomach and intestines of a poisoned person should be cut into fragments and boiled with potash previous to the usual test experiments. Orfila's sole novelty is, that he takes the whole body.

"Again—Orfila claims the idea of the absorption of arsenic as original. But such was the opinion in the days of even Ambrose Paré; and it was thus alone that the fatal effects of arsenic when applied to the skin, the vagina, or the rectum were explained."

Be it so. "But this suspicion was founded on physiological inference, and not on any ascertained facts."—*British and Foreign Medical Review*, No. 21.

On the other hand, many eminent chemists have of late years analyzed bone without finding arsenic in it. Dr. Schafhaeult of Munich observes, that he has not analyzed modern bones, but in examining those from a tumulus of a German or Celtic tribe, as well as from a Roman tomb, he could not detect a trace.—(*Lancet*, November 18th, 1840.)

Dr. George O. Rees followed precisely the directions of Orfila in all respects, but could obtain nothing like the metallic ring, although the plate was held directly in the flame. He observed in some instances an opaque white crust resembling arsenic, but it proved to be phosphate of lime carried up by the burning hydrogen. Again—the sulphate of zinc was occasionally thrown upon the test plate in the form of oxide when the escape of the gas was at all rapid. On applying the ammoniacal nitrate of silver to it, there was a faint white cloud, not unlike the arsenite of silver before it collects and shows its yellow colour.

From comparative experiments on a portion of diluted arsenical sulphuretic acid, he proved that sulphuretted hydrogen was a more delicate test than Marsh's apparatus. He obtained a yellow precipitate with the one, while the other failed to yield any result. He then took 7000 grains of Bone ash, (double the quantity recommended by Orfila,) and having proceeded through the preliminary steps required by that experimenter, subjected portions of the filtered liquor to each of those tests, but in neither was there any indication of arsenic. (*Guy's Hospital Reports*, No. 12, p. 163.)

To obviate any difficulty in medico-legal cases, Devergie advises that we should carefully remove every portion of bone that may be present when we operate on the internal organs.

The Muscles.—Orfila leaves this in doubt. Devergie took fifteen pounds of flesh from the body of a person who died of pulmonary congestion, cut them in pieces, boiled, and then evaporated the decoction down to one pound five ounces. This was carbonized with four pounds of pure nitric acid, the product treated with water, and then submitted to Marsh's apparatus. From fifteen to twenty brilliant stains were produced which he confidently considers arsenical. Orfila, in his reply to Devergie, asserts that he is now satisfied that the muscles contain the poison, but in quantity excessively small.

Neither of these individuals, however, relies on this result as a proof, and Orfila expressly recommends that the examination should be omitted when we have the viscera to operate on.

Dr. Smith (*Silliman's Journal*, vol. xl, p. 281,) observes, that many have supposed these stains to consist of sulphur with an infinitely small portion of arsenic. Others ascribe them to sulphur or phosphorus.

The deductions to be made in the present state of our knowledge are then the following:—It is not proved that bones in the natural state contain arsenic—it is very doubtful whether the muscles do—and it is certain that the *organs do not contain the least trace.* The application of this in legal medicine is evident. The experiments should be confined to the viscera.*

* There is an idea advanced in the *Lancet*, (January 2, 1841,) which should certainly be communicated to both Orfila and Raspail. It is this. Orfila has uniformly found a small quantity of arsenic in the bones. May not this metal be a constituent in garlic, of which the French eat so much? "If so, it will account at once," (says

3. *The presence of Arsenic in the earth of Grave-Yards.*—It will be recollected that Orfila could not obtain a trace when he treated the earth either with cold water or boiling water; but succeeded by the use of sulphuric acid. The stains however were so small as to produce the suspicion that they were ascribable to the sulphuric acid. Devergie proposes to substitute muriatic acid, and he remarks that in every case the inquiry must be twofold—whether a soluble or an insoluble arsenical compound be present. In the one case a solution is made and then subjected to the subsequent processes; in the other, the earth must be treated directly with the acid. The action of arsenic on the earths is not much understood, but from a single experiment, it would seem that arsenite of ammonia decomposes sulphate of lime, and arsenite of lime is formed. Orfila denies this, and states that even on carbonate of lime the action of the arsenite is slow and difficult. Both seem to agree that in all cases, (except those where arsenical minerals are present,) the arsenic is derived from the fragments of bones decayed by long burial.

But can *earth containing either the soluble or the insoluble arsenical compound yield it to a body buried in it, so as to make it doubtful whether the case is one of poisoning or merely of imbibition?* To test this, Orfila dug a hole three feet deep in a garden, watered the bottom with eight grains of arsenic dissolved in three ounces of water, then placed on it a human liver, and covered it with two inches of earth watered as above; and then filled up the hole. Eight days after, he watered it with two gallons of water, and soon after with eighty grains of arsenic, dissolved in water, making a total of 96 grains. Nine days after portions of the earth on the surface, a foot below, and also that in immediate contact above and below the liver were examined, all contained arsenious acid, soluble in boiling water, but not a trace could be detected by nitric acid and Marsh's apparatus, in the liver, although putrefied, and the parts examined were from the upper and lower surface. Devergie pretends to contradict this, from having immersed various organs, such as the liver and the kidneys, in a solution of arsenic, and then subsequently obtaining it. The reply of Orfila is satisfactory on this point. He endeavoured to imitate what might occur in the ordinary course, to bodies interred. The penetration of arsenic when the organs are immersed in it, is a totally different matter.

On the whole, Devergie is of opinion, that the arsenical compounds found in the earth, are generally insoluble ones, as the arsenite or arseniate of lime, and that it is difficult to suppose that rain can carry this into the decaying body so as to make the matter doubtful. Recollect that the liver in poisoned individuals, contains the largest proportion of arsenic, a condition that could not occur from imbibition merely.

It is also asked whether a poisoned body may not after a long burial lose the arsenic that it contains. Both disincline to this opinion. Putrefaction converts arsenious acid into arsenite of ammonia, and there can be no reason assigned, why this should not continue in the remains, as long as any visible traces of them are to be seen.

4. *Will the detection of arsenic be of any value, if it has been used as a medicine?*—Devergie says not, and declares that we have as yet no

the correspondent,) "for the arsenical condition of the bones of that nation—and also for the garlic smell!"

means of solving the question satisfactorily. It hence is necessary in all cases, to make the inquiry whether arsenic has been employed for that purpose.

But a new difficulty has lately occurred, in consequence of the employment of hydrated oxide of iron as an antidote. Many kinds of iron, as we shall presently see, contain arsenic, and it has been urged that the stains may be produced by the antidote. To ascertain this, Orfila subjected both forms of the peroxide, (by precipitation and by heat), colcothar, and sulphate of iron, to Marsh's apparatus without any effect. But when he administered colcothar to dogs and afterwards destroyed them in one, two and three days, although he found no traces of arsenic in the viscera, yet the fluid of the stomach and intestines in one case and the urine in another, yielded the stains. Dr. Smith, from whom I take this (Silliman's Journal) remarks that it is thus proved that colcothar sometimes contains arsenic in minute quantities, so small however, that the organs scarcely retain it, but give it off by the urine.

The medico-legal examiner must therefore test the remains of the antidote, to ascertain whether arsenic be present. (It is not always found). And again, he is once more taught to rely principally on the examination of the viscera.

5. *The purity of re-agents.*—If these contain arsenic, all our experiments are useless. As to *sulphuric acid* the testimony against it seems to be increasing. Dr. G. O. Rees (*Lond. Med. Gaz.* vol. xxvii, p. 723) has found much in the commercial article, by computation 22.58 grains of arsenic in twenty fluid ounces. He even obtained it in sulphuric acid purchased at Apothecaries' Hall, but not in the high priced article. Mr. Watson of Bolton Le Moors (*ibid.* p. 784) confirms this, and states that he has detected much larger quantities, and he and Mr. Blair, a manufacturer of the acid, have obtained a patent for purifying it of the poison. Both these gentlemen ascribe the presence of arsenic, to the acid having been made from pyrites instead of Sicilian sulphur. Devergie seems doubtful whether we can by any process free it completely, and therefore recommends the employment of another acid, the muriatic. All that we can do, according to him, is to distil it three or four times. Dr. Rees and Mr. Watson however both state unequivocally that muriatic acid also, contains arsenic.

Orfila persists in asserting that sulphuric acid can be perfectly purified, and adds that he has proved this by experiments on a large scale. He could not obtain a stain from several pounds, used in operating on earths. It is evident in every case, the sulphuric acid, as well the other acids employed, should be previously tested by Marsh's apparatus. It is generally conceded that *nitric acid* is pure. *Muriatic acid*, if doubtful, should be distilled. *Zinc* should be tested like the acids. And it must be renewed with every successive experiment. Mohr and Liebig, found that during the decomposition of arsenic acid and the soluble arseniates by zinc and sulphuric acid, a portion of the metallic arsenic deposited itself on the zinc. (Devergie.) Dr. Geoghegan of Dublin has made a similar remark. (*British and Foreign Medical Review*, vol. xi, p. 46.)

The presence of arsenic in many of the best qualities of English, Swedish, and French iron, has been proved by the experiments of Dr. Schafhaeult. (Report of the British Association, 1839, appendix, p. 52. *Lancet*, November 28, 1840.) It cannot indeed be denied, although it is

far from being universally the case. This, however, is not sufficiently to the purpose. I do not, says Orfila, deny that iron vessels contain arsenic, but the question is, whether the boiling of animal matters in them, in the manner proposed, will extract a single atom of it? It is highly improbable.

It is evident from this review, that no chemist, in a medico-legal case, should venture on an investigation, unless he has previously satisfied himself of the purity of his tests.

6. *Marsh's Apparatus.*—The reader who has followed us thus far will recollect that the notice of this was postponed, and I therefore resume, in the first place, the examination of Orfila's remarks on it. He does full justice to Mr. Marsh, but adds that he soon experienced great difficulty in the experiments. If the poison be mixed with organic matters, so large a quantity of froth (*mousse*) is produced, that the gas will not burn. Marsh was aware of this, and advised the pouring on of a stratum of olive oil, to prevent the formation of the froth, but even this was hardly effective. Devergie could not succeed with it, and employed as a substitute the essential oil of turpentine. A few drops were sufficient, but unfortunately it seemed to decompose the arseniuretted hydrogen, as no arsenic was deposited. It was therefore destructive to the experiment. The reviewer in the British and Foreign Medical Review states, that the production of froth is easily avoided by pouring a small quantity of pure alcohol on the surface of the liquid.

To obviate these impediments, Orfila resorted to the modes already mentioned of destroying the animal matter, first by nitre, and latterly by nitric acid.*

He also employed a simpler form of apparatus, which was suggested by Chevallier. Take a wide mouthed bottle and close it with a cork, which is pierced with two holes. Through one is passed a straight, funnel mouthed glass tube reaching to the bottom of the bottle, and through the other a tube bent at right angles, the perpendicular part ending just below the neck of the bottle, and the horizontal tapering to a fine point. From this last the gas issues. Test the purity of the materials by forming hydrogen alone, and after the mixed air in the bottle has been allowed to escape, fire that gas. Bring near to the end of the flame, a cold plate or capsule of porcelain. If, at the end of two or three minutes, metallic arsenic is not deposited, we may feel assured that the reagents are pure. Now add the suspected fluid through the long tube. We should endeavour to obtain a moderate flame, else the arsenic will volatilize and not

* Devergie proposes the following process, founded on the fixity of arseniate of lime, and its resistance to a high temperature. The animal matters may thus be burnt, while at the same time there is no risk of losing any arsenic by evaporation. He dissolves the animal matter with caustic potash. This produces arsenious acid and arsenite of potash. Add nitrate of lime in a proportion that represents two-thirds of the animal matter; pour water on it and the whole becomes of a pasty consistence. A double decomposition occurs. Arsenite of lime and nitrate of potash are formed. Dry the mixture and apply heat: the animal matter will burn at the expense of the nitric acid of the nitre. When the residue has become cool, pour on it, drop by drop, muriatic acid, until all effervescence ceases. Dilute with water, and you will have a liquid, blackened with carbon, which, on being filtered, must be introduced into the apparatus and treated with muriatic acid. *Annales*, vol. xxiv, p. 139. Orfila allows scarcely any merit to this process, and urges that the carbonization must be incomplete, and that a discoloured (red or black) liquid is produced. It is certainly more complicated than the nitric acid process.—*Ibid*, vol. xxiv, p. 299.

deposit itself. And again, the capsule should be held close to the flame where it issues, since if placed too near its extremity, the metal is apt to oxidize.

If the materials employed will furnish any additional gas, Orfila advises that a glass tube, two or three feet long, and from four to six lines wide, open at both ends, be presented horizontally to the flame. Arsenic will be deposited on its sides. When sufficient is collected, introduce a small quantity of nitric acid, pass it over the arsenic, and dissolve the whole by the heat of a spirit lamp. The liquid thus obtained should be evaporated in a porcelain capsule. Dissolve it in boiling distilled water, and treat it with sulphurretted hydrogen gas, to which a drop of muriatic acid has been added. (*Annales d' Hygiène*, vol. xxi, p. 452.)

Devergie prefers a bottle with two mouths, as he has found it less liable to break. He also advises the use of granulated instead of laminated zinc, as the acid acts more readily. Orfila denies this, and asserts that the granulated is less pure. If the quantity of arsenic in the suspected fluid be small; it will require, according to Devergie, at least eight, ten, or fifteen minutes, to procure the spots. As a general rule, the operation should be continued at least half an hour. The flame should not be more than two or three lines, otherwise the heat may be so great as to melt the extremity of the glass tube. If this happen, it should be carefully filed off. In using the porcelain plate, apply it successively to the extremity of the flame, its centre, and near the end of the tube. According as the stains are formed most brilliantly, there finally retain it. (*Annales*, vol. xxiv, p. 146.)

Lassaigne, an able analytical chemist, has also repeatedly signified his approbation of Marsh's apparatus. In a late communication, he states that the limits of its power is the detection of one two millionth (of a grain I presume) of arsenic dissolved in water, provided that we attend to the following circumstances—that the flame be not too strong or too feeble —that the porcelain plate be held so inclined as to cut off and intercept the flame—and that we seize the precise moment when the arsenic is decomposed and passes into the state of arseniuretted hydrogen. The precursor of this is the formation of a light gray irised spot. (*Annales*, vol. xxv, p. 223.)

Nature of the stains.—The next inquiry is, whether these are certainly arsenical. Can they be confounded with any other substance? Soon after the promulgation of Marsh's apparatus, Mr. Lewis Thompson stated, that if *antimony* was similarly treated, it would form stains strongly resembling those of arsenic. (*London and Edinburgh Philosophical Magazine*, vol. x, p. 353.) It is remarkable that his name is not mentioned by any French writer, except Raspail, that I have consulted. Mr. Thompson proposes the following comparative experiments. Treat the crust with nitric acid; this will dissolve both. Then pass sulphuretted hydrogen over a portion of the liquid, and if it consist of arsenic a ferment is produced, soluble in ammonia. Evaporate another portion to dryness, add a dilute solution of nitrate of silver, and expose the whole to the fumes of a stopper moistened with ammonia. If it be antimony, a dense white precipitate will be formed; if arsenic, canary yellow flocculi.

The characters assigned by Orfila, are as follows. The stains of arsenic are of a fawn brown, and extremely brilliant; if the arsenic be abundant, they are black and brilliant; those of antimony are of a deeper black and

less brilliant and never of a fawn brown, unless the quantity of that metal be extremely minute. An arsenical stain will be entirely volatilized by the flame of hydrogen gas, in from half a minute to a minute; antimony requires five or six minutes, and then changes to the white oxyd, which is volatilized, but a grayish yellow spot remains. Both dissolve readily in two or three drops of nitric acid, and on applying heat, the acid is drawn off, the arsenic presents a white residuum (arsenic and arsenious acids) and the antimony a yellow one (yellow oxide); if we add a drop of the solution of nitrate of silver to each, the antimony undergoes no change, but the arsenic presents a brick red arseniate, mixed with yellow arsenite of silver. If a drop of ammonia be now poured on the arseniate, the red colour becomes clearer, while if the same be applied to the oxide of antimony mixed with nitrate of silver, it instantly becomes blackened.

Subsequently our author has proposed the application of sulphuretted hydrogen to a separate portion, as advised by Mr. Thompson. Dissolve the residuum obtained with nitric acid in boiling water. The gas gives the yellow sulphuret of arsenic in the one case and an orange red precipitate in the other.

In his reply to Devergie, Orfila adds the following:—Arsenical stains do not evaporate sensibly in the cold—he has known them persistent on porcelain at the end of several years, with their brilliancy but little impaired. They do not attract moisture, neither do they redden litmus.

Devergie remarks that arsenical spots have three shades of colour, chocolate brown, slate brown and yellowish. The two first are peculiar to the metal. The last are probably not pure, but owe their shade to a combination of animal or vegetable matter with the arsenic. Antimonial stains are of a slate blue, occasionally brilliant, but generally covered with a black substance, of the appearance of charcoal. They are well defined to their edges, whilst the arsenical ones often diminish in intensity towards their circumference.

Unfortunately, Orfila has ascertained that numerous other substances produce stains, when similarly treated. In his first memoir (*Annales*, vol. 21, p. 455) he candidly states, that when the materials employed contain foreign and particularly organic matters, although perfectly free from arsenic, stains are produced, resembling it in colour. They are however, deficient in brilliancy, cannot be volatilized, and do not disappear by heat like those of arsenic. He called these *laches de crasse*, an appellation sneered at by Raspail on the trial of Mercier, who said that the term *crasse* was not to be found in any work on chemistry.

The attentive reader will also recollect the peculiar stains produced by the burning of muscle. They are exactly of that equivocal nature as to cause him to doubt whether arsenic did not exist naturally in it, and some suppose them to be a mixture of minute portions of sulphur and phosphorus.

The stains from *sulphur* are of a yellow colour, opaque, easily volatilized and insoluble in cold nitric acid. Those of *phosphorus* vary from brilliant yellow to red according to the quantity. As they almost constantly contain phosphoric acid, litmus paper is reddened by them. They also volatilize and are insoluble in nitric acid. *Iodine and bromine* also cause stains, but they are each yellow and extremely volatile. *Selenium* produces an opaque white spot, as does also *tellurium*. Even *iron* under some circumstances may cause one. It is described by Dr. Smith (*Silli-*

man's Journal) as black, slightly metallic, not volatilized by heat, soluble in nitric acid, and the nitric solution strikes a blue with ferrocyanuret of potassium.*

However positive the French chemists may be, that they can discriminate between these various stains, and particularly those of arsenic and antimony, yet it is not to be concealed, that others have not been so fortunate. As the quantity to be operated on, becomes more minute, the distinction diminishes, and yet this is precisely the case in which we need the most marked variety. For let it be remembered, that if any appreciable quantity collects on the stains, we are then able to apply the ordinary tests, or we may use them without resorting to Marsh's apparatus.†

To obviate these new difficulties, another modification has been proposed, Lassaigne and by Dr. J. Laurence Smith.

The former passes the gas disengaged from Marsh's apparatus into a solution of pure nitrate of silver, which it has the property of decomposing. The solution becomes brown and deposits oxide of silver in black flakes. Arsenious acid remains in the solution with an excess of the nitrate. After the gas has ceased to act, muriatic acid is added drop by drop to decompose the remainder of the nitrate and convert it into chloride. Filter and evaporate the solution which now contains arsenic and arsenious acids. Lassaigne has found this an extremely minute test. (*Annales*, vol. 25, p. 224.)

Dr. Smith proposes to pass the arseniuretted hydrogen through an alcoholic solution of iodine, which it also decomposes, and iodide of arsenic remains in solution. Evaporate this down until red fumes appear, and then add two or three times as much nitric acid as there is residue in the capsule. Applying heat again, when arsenic and arsenious acids will be found nearly pure. (*Silliman's Journal*, vol. 40, p. 291.)‡

Antimony.—Orfila has also published a Memoir on poisoning with Tartar Emetic. The following are his principal conclusions: 1. That tartar emetic, taken into the stomach or applied to the sub-cutaneous cellular tissues of dogs is absorbed and carried into all the organs of the animal economy, as Magendie had inferred, but not proved by his experiments. 2. That when inserted below the skin, two grains are sufficient to destroy a small sized dog, in from thirty to forty hours. 3. That it is not sufficient in suspected cases, to confine our examination to the matters vomited, or the fluid in the stomach and intestines, as the poison may be wanting in these and can still be found in other parts. 4. That among

* Even the porcelain capsules or plates may (as suggested by Dr. George P. Rees) if they are glazed with *lead*, cause mistakes. "If arsenic be present, the appearance obtained is liable to be in some measure obscured by the glazing becoming reduced—and when none exists, a dark metallic spot of reduced lead may readily be obtained by the action of the hydrogen flame on the glaze of the porcelain."

† Messrs. Danger and Flandin, in a paper read before the Academy of Sciences at Paris, Dec. 28, 1840, state, that they obtained stains with Marsh's apparatus—from sulphite of ammonia (made by saturating ammonia with sulphurous acid) to which a few drops of essential oil of turpentine had been added. These stains produced the garlic smell—and gave identical results to arsenic with nitrate of silver and sulphuretted hydrogen. Indeed when the mixture contained in addition, any trace of phosphite of ammonia, the experimenters could not discriminate between the two. *Gazette des Hôpitaux*, Dec. 23, 1840,

On referring to the trial of Mercier it will be seen that Raspail mentioned a somewhat similar result as obtained by himself.

‡ I have not thought it necessary to repeat Figuier's modification of Marsh's process, as it is stated in full in the last number of this Journal, p. 233.

the viscera, the secretory organs, and particularly the liver and kidneys are the parts in which it will remain longer than in any other. 5. That after having left the viscera, it is eliminated with the urine and probably with some of the other secretions. Tartar emetic passes off much more rapidly than arsenic. After the lapse of an hour, no trace of it can be found in the blood, while it may still be distinctly detected in the viscera and in the urine. 6. That if it be decomposed by the blood and the organs, this decomposition is not complete, since in treating these organs with boiling water, we obtain a liquid distinctly antimonial. It is possible indeed that the tartaric acid alone is decomposed and the salt itself reduced to a soluble hypo-antimonite of potash. 7. Several organs should be treated together in order to obtain as large a quantity as possible at once. Even when this fails, we may detect it in the fluid of the secretions, but particularly in the urine. 8. The process recommended is to carbonize the viscera, after they have been well dried, with pure, concentrated nitric acid; (as in the case of arsenic) to boil the carbon thus obtained, for half an hour, in muriatic acid, to which a few drops of nitric have been added; to filter the liquor and introduce it into Marsh's apparatus. Antimonial hydrogen gas will be produced, and on being inflamed it will deposit metallic stains, the nature of which may be ascertained by the distinctions already stated. In this operation, the tartaric acid is altogether decomposed, and the protoxide of antimony probably passes into the state of soluble antimonious acid, while the potash unites with the nitric acid.

In several cases, he succeeded in detecting the presence of the metal in human urine. To a patient affected with pneumonia, twenty-four grains of tartar emetic had been given in the course of twenty-four hours; Orfila obtained from the urine, a quantity of the metal sufficient to be exhibited to the members of the Academy. Again, the liver, spleen and kidneys, taken from an aged inmate of the Salpetrière, who died fifteen hours after having taken two grains, yielded distinct traces.

If metallic antimony be obtained by the above process from the viscera and urine of persons who have not taken its salts as a medicine, it proves that they have been poisoned, since neither of these otherwise contain a trace of it. (*Annales d'Hygiène*, vol. xxiii, p. 474. *Medico-Chirurgical Review*, vol. xxxvii, p. 431. *British and Foreign Medical Review*, vol. xi, p. 52.

Copper.—The novel points of inquiry relative to this metal, and indeed also, as to lead, are whether they are present in the human body in its natural state, and if so, whether there is any mode of discriminating between these, and their introduction as a poison? It may be useful to review our informatian on this subject, previous to stating the results obtained by Orfila.

Professor Christison, in the last edition of his valuable Treatise on Poisons (1836), observes, that Sarzeau, a French chemist, had just announced that a very minute quantity of copper may be detected not only in many vegetable substances, some of which are used for food, but likewise in the *blood and other fluids and solids of the human body.* Others, he adds, have not however been so successful. In an examination, made some years previous, he failed, although his means of analysis were ample, to detect it in the blood, muscles or spinal marrow of animals. Chevreul was unable to obtain the slightest trace in beef, veal or mutton. This discrepancy is attempted to be explained by the idea that vegetables will only

contain it, when it has been present in their manure, while animal bodies may thus also exhibit a trace, either from feeding on those vegetables, or from its being received from the copper vessels used in preparing or preserving them.

In October 1838, Devergie published a note, to the effect that having in two successive instances of supposed poisoning, obtained copper from the stomach and intestines, he was led to inquire how far this might naturally be present in a body free from all suspicion of poisoning. In conjunction with M. Hervy, the investigation was undertaken and they were greatly surprised to find both copper and lead, generally present in variable quantities. These metals were obtained from the bodies both of men and women, from persons dying of illness, and suddenly from hanging: also from a youth aged fifteen years, from children aged twenty months and twenty days, and in one case, in a new born infant. Several of the organs and tissues of the body were proved to contain these metals. In September 1838, he was directed with Orfila, Ollivier and Bayard to examine three several cases of poisoning, and in each of these, although arsenic was proved to be the cause of death, yet copper and lead were also found. (*Annales d' Hygiène*, vol. xx, p. 463).

Cattanei, Professor of Chemistry at Pavia, observing a notice of these experiments, proceeded to institute similar ones, with the assistance of Platner, professor of legal medicine.

Supposing it probable, that if present, the copper might have been introduced with the food, or from accidental sources, he determined to examine the bodies of infants that had died soon after birth and taken nothing but their mother's milk.

The stomach and intestines of a seven month's child, which survived only two days, the lungs and heart of another of the same age, living only two days, and the lungs, intestines, liver and spleen of a child at the full time, that survived twenty-five days, were each carbonized separately in Hessian crucibles, and the product incinerated, in one instance, with nitric acid, and in the others with chlorate of potash; acetic acid was now poured over these ashes, and its action assisted by heat. To this liquid, ammonia in excess was added. The fluid thus obtained, was tested with the yellow bicyanuret of potassium, with sulphuretted hydrogen and with a plate of polished iron. No effect was produced. The matter, obtained after decantation, was then tested for lead, with iodide of potassium, chromate of potash, sulphuretted hydrogen and a plate of zinc, but with equal ill success. He therefore concludes that not a trace of copper or lead existed in the viscera. It was his intention to have extended the inquiry to the bodies of adults, but he was deterred, by observing a notice, that the academy had reported unfavourably to the opinion of Devergie. (*Gazette des Hôpitaux*, May 21, 1840. *British and Foreign Medical Review*, vol. xi, p. 226.)

The subsequent experience of Devergie is however in full accordance with his first statement. In a communication, published in July 1840, he asserts that he has continued to find both the metals in the organs and in the blood, during multiplied investigations, in persons of all ages, dying either suddenly, or after a long illness. It would seem however that the proportion increases with age and probably also with disease. Four pounds and a half of healthy blood gave scarcely a trace of either, while a notable quantity of lead was present in one pound taken from a person

dead from a saturnine disease. In this individual also, copper was found in the fecal matters, although it was nearly altogether wanting in the intestinal tissues. The following are some of the results obtained:

	Grammes.	Grammes.
	New born child.	
Intestinal canal, sulphate of lead,	0.001	Sulphate of copper, 0.001
	Child eight years old.	
Stomach,	0.004	0.005
	Healthy Female.	
Stomach,	0.020	0.025
Intestines,	0.030	0.035
Intestines,	0.040	0.046
	Male.	
Gall bladder,	0.003	0.002
	Female, dead of Phthisis.	
Intestines,	0.010	0.010
Brain (one pound),	0.006	0.010
A male dead from cerebral disease consequent on colica pictonum.		
Stomach,	0.030	0.020
Lungs (quantity imponderable.)		
Kidneys (eight ounces),	0.002	0.001
Fæcal matter,	0.029	0.030
Gall bladder and bile,	0.004	0.001
Bladder,	0.005	0.003
Muscle (one pound),	0.026	0.024
Blood (seven ounces),	0.050	0.044*

The process now pursued by Devergie, is to dry the animal matter and then calcine it in a porcelain crucible, by a red heat, until the incineration is complete. To this, water is first added to dissolve the soluble salts, and afterwards muriatic acid. Heat is then employed to evaporate the major part of the acid, and the residue, slightly acid, is submitted to the action of sulphuretted hydrogen. The precipitate is of a chocolate colour or black, according as copper or lead predominates. After being allowed to subside, it is collected in a small porcelain capsule, with a little water, to which a few drops of muriatic acid, and one or two of aqua regia are added. The sulphur is thus removed; the liquor is then evaporated to dryness, to volatilize, the acid and the lead is precipitated by sulphuric acid, while the copper remains in the solution. Each of these are then separately dried or evaporated, in order to obtain their quantity by weight. (*Annales d' Hygiène*, vol. xxiv, p. 180.)

We now return to the investigations of Orfila, and the following case deserves the first notice, more particularly as it seems to have given rise to the extended researches on poisons, which form the main subject of this article.

Schneider, an oculist, and Rittinghausen, a lawyer, (doctor of laws,) travelled together, for a number of years, as friends and companions. The former was taken ill at Lyons, on the 7th of September, 1835, with feverishness, headache, nausea, &c. He was, however, able to travel to Dijon on the 11th inst., and where he arrived on the next day. The illness assumed a more serious appearance. Dr. Laplaigue, a homœopathist,

* A French gramme, since January, 1840, is equal to twenty grains. (*Medico-Chirurgical Review*, vol. xxvii, p. 529.)

was called in, who administered, during his attendance, six globules of aconite, eighteen globules of belladonna, in four doses, (38th dilution;) six globules of cinchona, three of arsenic in two doses, and two globules of rhus toxicodendron. On the 24th Schneider died. Rittinghausen had waited on him with great assiduity, until the 21st, when beholding the hopeless condition of his friend, he left suddenly for Neufchatel, in Switzerland. The body was buried, but disinterred eight months afterwards, on suspicion of poisoning. A commission, consisting of Sené, Payen, and Fleuret, were appointed to make a chemical examination. They reported that they had found copper and lead in the intestinal canal—and on this Rittinghausen was accused of murder. He was arrested in Belgium, by virtue of a demand from the French authorities, and committed to prison in Dijon. While in confinement he applied to Orfila for his opinion on the case, to which a voluminous, and on the whole, a favourable answer, was returned. The trial commenced on the 8th of August, 1838, and was continued on the 9th with the prospect (says Orfila) of an acquittal. On that night, however, the prisoner hung himself in his cell.

It is not necessary to analyze the communication of Orfila in detail. He renders it highly probable, from a comparison of the symptoms present, with those usually produced by copper and lead, that none of the latter had exhibited themselves, but that death had been caused by typhoid fever. He censures the medical examiners for neglecting to notice the condition of the viscera, since although considerable time had elapsed after burial, yet some inferences might still be deducible from their appearance. The main question however to be decided was, whether the presence of copper and lead in the intestinal canal was sufficient to prove that death had been caused by poisoning. Orfila inclined to the negative. The chemical examiners do not state the quantity found; it probably was small, and above all, it may have been taken as a medicine, in the form of a salt, or an oxide. Again, if the experiments of Devergie be correct, both these metals exist naturally in the tissues; and lastly, the lead present may have been derived from impure wines, used by the deceased before his illness, and the copper from bread and other vegetable substances, containing it, as proved by Sarzeau. (*Annales d' Hygiène*, vol. xxi, p. 127.)

The reader will appreciate the intention of these suggestions. So far as they throw doubts on the charge of poisoning, they tend to exonerate the prisoner. Devergie, however, expressly gives it as his belief, that the copper and lead found in the body of Schneider, was normal.

In compliance with his promise to the Academy, when relating the above case, Orfila pursued his examinations, and in June, 1840, read a memoir on the *method of detecting poisoning by copper, and how to distinguish this from copper naturally existing in the human body.* The following are the results of his experiments and observations.

The acetate and sulphate of copper, whether taken into the stomach, or applied to the sub-cutaneous cellular tissue of dogs, are absorbed and carried into every organ, and this is probably the case with man. In order to detect their presence, we must not confine ourselves to an investigation of the contents of the alimentary canal, or of the matter vomited, but should examine all the tissues into which they may have been absorbed.

Besides this absorption, and which is unequally distributed among the tissues, several organs (and particularly the abdominal viscera, if the salts have been introduced into the stomach) contain some of the salt, which

has reached them by imbibition after death. The nearer the parts are in contact with the stomach and intestines, the greater will be the quantity imbibed, and this will also vary with the period at which the body is opened. It is possible, in a majority of cases, to determine whether the cupreous salts have been introduced after death or during life, by attention to the symptoms, the structural lesions, and particularly by chemical experiments on organs remote from the digestive tube, rather than on one that is near it.

The *absorbed cupreous salt* may be detected by boiling the viscera or the flesh for an hour in distilled water, drying the filtered decoction and decomposing it by nitrate of potash, or carbonizing it with nitric acid. It must however be understood that this boiling for an hour will not dissolve every trace of copper *naturally* existing in our frame, and hence the examiner has a right to conclude that some preparation of copper has actually been introduced during life, either as a poison or a medicine, if he obtains copper from an aqueous decoction prepared as above, unless it be proved that the copper penetrated the tissues, in consequence of imbibition after death.

It is best to boil, in the first place, the viscera which are distant from the alimentary canal; next these portions of the abdominal viscera which have not been in contact with the canal, and then the parts which have been in contact with the stomach and intestines. By this operation we are certain to obtain from the latter a greater quantity of poison, and at the same time, solve satisfactorily the question of imbibition.

Again, if the medico-legal researches, instead of being directed to the alimentary canal, are directed to the alimentary or excrementitious substances contained in it, or to the liquor vomited, these substances must also be boiled for an hour in distilled water, and the decoction is to be filtered, evaporated down, and then decomposed by pure nitric acid, or by nitrate of potash. The presence of copper, after this decomposition, permits us to affirm that a cupreous preparation has been taken. Although boiling water dissolves only a small part of the salts of copper when they are intimately combined with organic matter, yet the solution contains enough to coat a polished plate of iron. And after a comparison of the different processes, Orfila came to the conclusion that this deposit of the metal on iron is the best test, when it exists only in minute traces.

Such then is the mode proposed by our author to distinguish between *copper naturally existing* and *copper taken as a poison*. In the latter case it may be obtained in part from the viscera boiled in water for an hour; in the former this process has no effect, and to develop the presence of the metal, incineration is necessary. On this account he objects to the process of Devergie, although admitting with him, the existence of copper in the natural state. A difficulty of the following description may occur. The quantity of poison existing in the intestines of a *non-poisoned* adult does not exceed 46 milligrammes, (nine-tenths of a grain;) but even this, from the experiments of Devergie, is variable. If then we proceed to carbonize the whole of the animal matter, and estimate the amount obtained, it may happen that a small quantity left after poisoning by a cupreous salt, in the intestines, added to that naturally existing, may actually amount only to the maximum indicated by Devergie.

In the animals poisoned, and which formed the subjects of the experiments detailed in this paper, the following plan was resorted to for detect-

ing copper. "The viscera were cut into pieces, and boiled for six hours in a quantity of distilled water, acidulated with a few drops of nitric acid. The decoction was filtered, and evaporated to dryness. The dry residue was carbonized by heating it in strong nitric acid, and the carbonaceous ash was then treated with muriatic, mixed with a few drops of nitric acid. This was filtered, and again evaporated to dryness; the residue was then dissolved in water, acidulated with sulphuric acid. On introducing a piece of polished iron into this liquid, a certain quantity of copper was deposited on it in the course of an hour. Much longer time is, however, sometimes necessary, when the quantity is small."

In this way, copper was detected in the lungs, heart, liver, spleen and kidneys of animals experimented on, but there was no satisfactory evidence of its presence either in their blood or urine. (*London Medical Gazette*, vol. xxvi, p. 637; *British and Foreign Medical Review*, vol. xi, p. 55.*)

Lead.—As to this metal, a part of the observations made on it by Devergie have been already necessarily anticipated. The most striking additional fact adverted to by him, is, that there appears to be more lead present in the healthy state, than in the diseased, even when the disease has its origin from that substance.

Merat and Barruel, examined carefully the urine of an individual labouring under colica pictonum. The fecal matter passed during eight days by the action of purgatives, were also incinerated, and the ashes treated with nitric acid, but in neither case was a trace of lead to be observed. Tiedemann and Gmelin, obtained lead from the blood of the splenic, and mesaraic veins of dogs poisoned with the acetate, but could not detect it in that of individuals labouring under colica pictonum. Chevallier failed in a similar case.

In only a single instance, subsequent to the experiments of Devergie, has the search proved successful in the diseased, and that was a case of saturnine epilepsy. Guibourt calcined the brain, and acting on the ashes with muriatic acid, passed through the solution, a current of sulphuretted hydrogen. Sulphuret of lead was thus obtained.

Devergie infers from these results, that long protracted disease diminishes the quantity naturally existing in the body, and as but little food is then taken, it seems most probable that the source of the copper and lead, are the viands and vegetables, which are taken for nutriment. (*Annales d'Hygiène*, vol. xxiv, p. 187.)

The investigations of Orfila were caused by the Rittinghausen case, and the question which he particularly wished to examine, was whether, in an instance of poisoning by the salts of lead, copper, or any other metal, it could be ascertained that the poison had been introduced one hour or twelve hours—or two, three, fifteen or twenty days after death?

It is not necessary to go into the details of his experiments. Their results are thus summed up by him. In animals killed two hours after taking a small dose of the acetate of lead, white streaks and spots were visible to the naked eye, on the mucous membrane of the stomach, and sometimes

* There are some curious experiments by Lefortier, on the salts of copper, mentioned in the Summary of this number.

on that of the intestines, and these were found to consist of organic matter combined with salt of lead. When sulphuretted hydrogen was applied to them, sulphuret of lead was instantly produced, and although insoluble in both cold and boiling distilled water, yet with diluted nitric acid, they yielded nitrate of lead.

The same alterations were observed, when the animals were allowed to live four days only, but the points were less numerous, and visible only by the help of a lens. Sulphuretted hydrogen, blackened them. In a third class allowed to survive seventeen days, these appearances were no longer to be seen. Sulphuretted hydrogen produced no effect, but when the stomach was boiled for half an hour in diluted nitric acid, there was a notable product of nitrate of lead.

We may thus form an opinion approximatively of the period at which the poison has been taken, by comparing the parts with the conditions stated above, and we have also grounds for believing that after a certain time, the combination in question altogether disappears.

Orfila further infers that the alteration occurs, independent of vital action, as it was developed in a stomach detached from the body, and that the same result happens, whether the salt be allowed to act in greater or less quantity. In one instance, he noticed these white spots seventeen days after burial, and in another, after thirty-eight days' exposure of the stomach to the air.

If we admit with Devergie, that the digestive canal naturally contains a small portion of lead, we have here a ready mode of distinguishing between it, and the metal when introduced as a medicine, or a poison. In the former case, the white spots will be wanting—nor will the treatment with nitric acid develop its presence. But it will be unsafe in medico-legal researches, to rely on the *quantity* obtained, since so much may have been evacuated by vomiting or purging, as to make the residue, added to the variable normal portion, only equal to what sometimes is present in the healthy state. (*Annales d'Hygiène*, vol. xxi, p. 149. *Mémoire sur l' empoisonnement par les sels de plomb*, par M. Orfila.)

The following curious fact, related by Mr. Alfred S. Taylor, (*Guy's Hospital Reports*, No. 12, p. 175,) deserves a place under this head.

A cow swallowed a quantity of carbonate of lead which had been mixed for paint. It is supposed that she took about half a pound. Obstinate constipation, and a general paralysis of the trunk and limbs succeeded, and she was with difficulty recovered by sulphate of magnesia, sulphate of soda, and other remedies, at the end of ten weeks.

Soon after the animal had taken the poison, and while still labouring under its effects, a quart of milk drawn from it, was sent to Mr. Taylor for examination. An ounce deprived of cream was treated with hydrosulphuret of ammonia, and sulphuretted hydrogen gas, but in either case without effect. Judging from these results, that if lead were present, it must be in very small proportions, he passed the gas into about ten ounces of the milk. In a short time, the liquor assumed a faint brown colour, and after a few hours, a black flaky precipitate collected at the bottom of the vessel, but in so small a proportion that it was impossible to verify it by using any of the usual tests for sulphuret of lead. On adding, however, a very small portion of a diluted solution of a salt of lead to another quantity of pure milk, the effect produced by the gas was precisely similar.

From these results, Mr. Taylor is of the opinion that some traces of lead, but infinitesimally small, were present in the milk.*

T. R. B.

* The following case of poisoning with the acetate of lead, in which the poison was detected in the urine, by MM. Orfila and Villeneuve, should be added as a supplement to the above.

"A girl, in a fit of despair, swallowed between eight and ten drachms of the super-acetate of lead. She was speedily affected with prostration of strength, paleness and coldness of the surface of the body and faintings, which symptoms were in a short time succeeded by vomiting and præcordial anxiety. Sulphate of soda was given in large and repeated doses, and was followed by copious alvine evacuations. Under this treatment the poisonous symptoms went off, and the temperature of the body returned. The urine which the girl passed twenty-five hours after swallowing the poisonous dose was examined by M. Orfila, who extracted from it a considerable quantity of lead, showing that the poison which had been absorbed was thrown off from the system by means of the kidneys.

M. Lassaigne of Alfort made a number of experiments at the veterinary school there, with the view of ascertaining in what secretions or organs the lead with which animals have been poisoned is found. He constantly met with it in large quantity in the venous blood and in the urine of living animals, and in the liver and kidneys after death.

MM. Chevallier and Bricheteau have examined the urine of the workmen in the lead manufactories, especially at the time when they were affected by this metal, but have as yet, been unable to detect it even in the most minute quantity in that fluid. M. Orfila, also, was unable to detect its presence in the body of a child supposed to have been poisoned from breathing its vapours.—*Ed. Med. and Surg. Journ.* April, 1841, from *Bull. de l'Acad. R. de Med.* Jan. 1841.